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Nonwoven geotextiles used for temporary reinforcement of a retaining structure under a railroad track

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ABSTRACT: In the course of the lifting and widening of a railroad track in Vienna a temporary retaining wall 2,1 m high had to be constructed. Due to the limited time and space available the wall was built using nonwoven needlepunched continuous filament geotextiles as reinforcing elements. In spite of the heavy traffic load, measurements have shown that deformations of the structure were negligible, proving that even low modulus nonwoven geotextiles can fulfill reinforcement functions, especially in low, temporary structures.

1 SITUATION

The construction of the hydro-power station „Freudenau" on the river Danube in the city of Vienna made it necessary to lift all bridges by up to 4,36 m to allow ships to pass through. One of these bridges crossing the Danube was a railroad bridge of the „Ostbahn"-lane leading from Vienna to Bratislava and Budapest.

The ramps of the bridge had to be lifted accordingly, in combination with a widening of the track from 2 to 4 lanes incorporating a newly built municipal railroad line (S 80).

2 PROBLEM AND CONSTRUCTION RECOMMENDATION

The main problem for the consulting engineer was the fact that the traffic flow had to be maintained during construction, which made it necessary to split the construction works into various sequences. In one of the sequences it was necessary to build a 2,1 m high retaining wall over which the new track would take all the existing traffic (see Figure 1).

The structure had only temporary function. The maximum time for the wall to fulfill its function was planned to be less than one year.

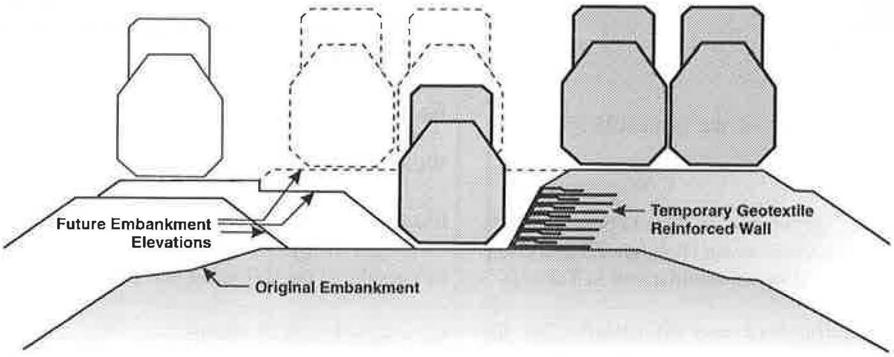

Figure 1: Schematic cross section

Taking into account the limited space available, the construction time and construction costs it was decided to build a geotextile reinforced earth structure rather than a sheet pile wall.

This construction method is already well proven for other application areas, such as road construction and landscaping, but for railroad construction with its high traffic stresses it was a new challenge.

3 DESIGN AND STABILITY ANALYSIS

3.1 *Structural layout*

The cross section of the retaining wall is illustrated in Figure 2.

The structure had a height of 2,1 m and a slope inclination of 63°. In order to allow adequate compaction of the fill material and thus restrict deformations, the lift thickness between each geotextile layer was designed to be 30 cm. The anchoring length was 1,7 m; this fulfills the requirement of $l_e > 0{,}7 - 0{,}8\ h$ to allow the stability calculation of a monolithic retaining structure by conventional design procedures [1].

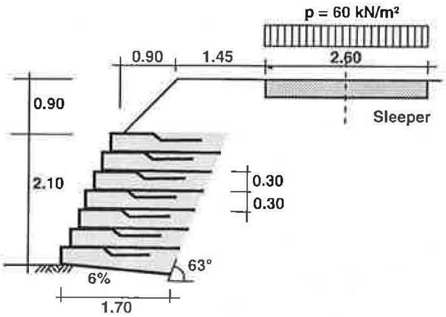

Figure 2: Cross section of the geotextile reinforced earth structure

As reinforcing geotextile a needlepunched PP continuous filament nonwoven (Polyfelt TS 800) was used. The technical data are summarized in Table 1.

The external traffic load was 60 kN/m^2. The fill material used both within and behind the wall was a gravelly sand having the following shear parameters:
$\varphi = 35°$, $c = 0$,
$\gamma = 21$ kN/m^3

Table 1. Mechanical and hydraulic properties of the geotextile (Polyfelt TS 800)

Tensile strength	23 kN/m
Elongation at break	45 %
CBR puncture resistance	3800 N
Transmissivity	2 x 10^{-5} m²/s
Mass per unit area	400 g/m²

3.2 *Internal Stability Analysis*

The internal stability was checked using the lateral active earth pressure method [3]. In this method, the total active earth pressure is calculated which has then to be taken up by the reinforcing geotextiles, taking into an account an adequate factor of safety.

As an simplifying approximation it was assumed that the earth pressure is uniformly distributed over the whole height of the wall. This is justified taking into account that the actual earth pressure distribution has a parabolic shape (see Figure 3).

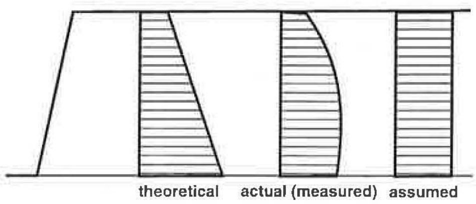

Figure 3: Theoretical, actually measured and assumed earth pressure distribution [4]

The soil shear strength parameters and the geometric boundary conditions yielded an active earth pressure coefficient of

$$K_{ah} = 0.103$$

With the additional virtual height

$$h' = (0.90\,\gamma + p) / \gamma = 3.76 \text{ m}$$

this results in the following horizontal earth pressures

$$e_{a1} = K_{ah}\,\gamma\,h' = 8.13 \text{ kN/m}^2$$
$$e_{a2} = K_{a}h\,\gamma\,(h + h') = 12.7 \text{ kN/m}^2$$

and finally the total active earth pressure

$$E_a = \tfrac{1}{2}\,(e_{a1} + e_{a2})\,h = 21.9 \text{ kN/m}$$

This was then evenly distributed over the 6 geotextile layers. With the ultimate tensile strength of 23 kN/m, the achieved factor of safety was

$FS = 6\,T / E_a = 6.3$

This was greater than 4 which is usually recommended for geotextile reinforced, temporary earth structures.

3.3 *External Stability Analysis*

The external stability of the monolithic structure was calculated using conventional computerized design programs [2]. The basis for the design is illustrated in Figures 4 and 5.

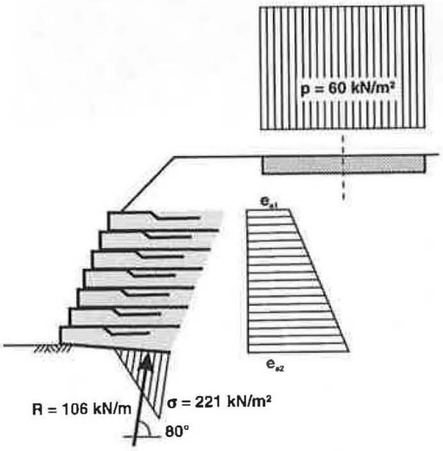

Figure 4: Forces for evaluating the stability against bearing capacity failure [2]

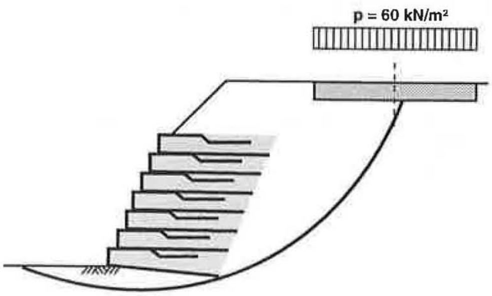

Figure 5: Overall stability: critical slip circle [2]

The following factors of safety were achieved:

Bearing capacity failure:
$FS = 1.63 > FS_{reqd} = 1.5$

Overall stability:
$FS = 1.29 > FS_{reqd} = 1.2$ (temporary structure)

4 CONSTRUCTION

The individual layers of the retaining structure were built using a removable formwork consisting of steel angles and wooden bars as illustrated in Figure 6. To achieve adequate friction between the adjacent geotextile layers a thin layer of sandy gravel was placed on each lift prior to the installation of the next one.

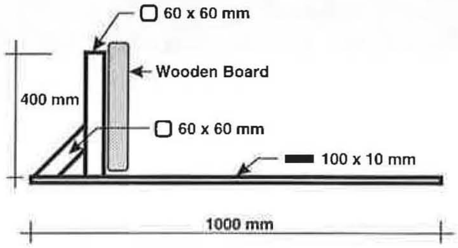

Figure 6: Formwork for construction

As the structure had to fulfill only a temporary function (service life time less than one year) the installation of a surface protection could be omitted, because of the use of a UV stabilised geotextile.

After the structure has finished its function as temporary retaining wall, the geotextile layers will be cut during the fill of the adjacent embankment in order to allow good interlocking of the fill materials.

5 MONITORING AND MEASUREMENTS

For such high traffic stresses there was no practical experience available, therefore weekly settlement measurements were carried out on 6 points along the 100 m long embankment. In four of these points the measured settlement was nil, in the two other points it was limited to 1 mm which is within the accuracy of measurement. This clearly shows that even low modulus geotextiles can be suitable reinforcing elements.

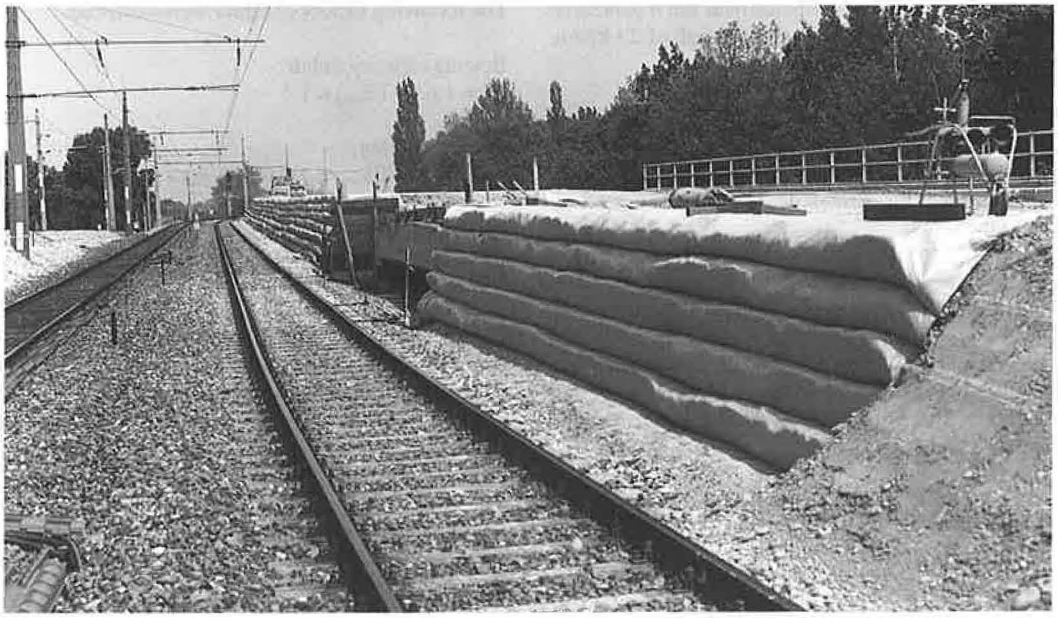

Figure 7: Typical view of the geotextile reinforced wall during service time

6 SUMMARY

- Nonwoven needlepunched geotextiles are a suitable material for the construction of geotextile reinforced earth structures. With a correct design they can be used even for structures with high loading requirements.

- Simple design methods (earth pressure method) can be applied when an adequate factor of safety is applied to the tensile strength of the geotextile.

- Provided carefull installation and good compaction of the fill material are achieved, the settlements of such a structure are negligible. These requirements are obligatory and of highest importance in any reinforced soil structure.

- Temporary geotextile reinforced earth structures using low modulus nonwoven geotextiles are a technically and economically sound alternative to sheet pile walls, based on quick installation and low demand for space. The actual in soil stress-strain beehaviour of nonwoven geotextiles made from Polypropylene shows an increase in modulus and significantly lower creep behaviour. [5]

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